BENTON HARBOR POWER PLANT LIMNOLOGICAL STUDIES

PART XXII. UNDERWATER OPERATIONS IN SOUTHEASTERN LAKE MICHIGAN NEAR THE DONALD C. COOK NUCLEAR PLANT DURING 1974

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TABLE OF CONTENTS

UNDERWATER OPERATIONS IN SOUTHEASTERN LAKE MICHIGAN NEAR THE DONALD C. COOK NUCLEAR PLANT DURING 1974

Abstract. Underwater operations in the vicinity of the Donald C. Cook Nuclear Plant began in 1973 and continued in 1974 and 1975. These underwater surveys permitted visual examination and handsampling of the area, which in turn may be correlated with mechanical sampling of the area. Eighteen dives were performed between April and October 1974 at locations within and without the riprap zone. Ten species of fish were observed: sculpin, johnny darter, alewife, yellow perch, lake trout, burbot, emerald shiner, channel catfish, black bullhead and carp. Slimy sculpin eggs were collected in the study area during May; spottail shiner eggs were collected in June. In both cases, samples of each species of egg were retained in the laboratory, where limited hatching subsequently took place. Crayfish and one species of snail, *Physa integra*, were frequently observed in the riprap zone, never outside it. Samples of algae and periphyton were collected from the study area; 39 species of algae and diatoms were identified in samples taken from the riprap zone. However, only one algae (*Spirogyra*) was collected outside the riprap zone. This algae was unattached and possibly washed into this area. Diversity of fish species, abundance and activity levels of fish, snails and crayfish, and the density of algae were found to be higher within the riprap zone. Increases are attributed primarily to the presence of underwater structures and riprap surrounding these structures. Biological diversity, abundance and activity levels were much higher at night than during the day. Most areas of the bottom were free of decaying material. Macrophytes were not observed. The 1975 diving program objectives are outlined and include an intensification of the effort to quantify observations.

ACKNOWLEDGMENTS

We are greatly indebted for the support and guidance given to us by Erwin Seibel, who has been instrumental in the development of the diving program at the Great Lakes Research Division. Lee H. Somers deserves our appreciation for the hours he has spent training many of our departmental divers. We would like to extend special thanks to Jon Barnes for his assistance at the Cook Plant and during several of the dives. We are grateful for the time and effort expended by Marybeth M. Bowman during her analysis of the periphyton samples.

Special recognition is deserved by our fellow divers, Frank Tesar, David Jude and Gregg Gitschlag, who often endured unpleasant diving conditions, and without whose assistance diving operations at the Cook Plant would have been impossible.

INTRODUCTION

Underwater operations were conducted in the vicinity of the Donald C. Cook Nuclear Plant during 6 months of 1974. Eighteen dives to collect scientific data were made during April, May, June, July, September and October. The 1974 underwater survey program produced substantive results which permitted a comparison of 1973 and 1974 observations.

Data obtained through visual observations and handsampling were used to supplement and correlate with mechanical sampling data.

METHODS

Open circuit SCUBA was used for all dives, and a 16 ft Boston Whaler served as the primary support vessel. Although the 1974 field schedule originally called for 5-6 dives per month from April through November, inclement weather, limited visibility and problems associated with equipment and operational logistics forced a reduction of the diving schedule nearly every month. However, portions of the intake and discharge areas were examined in April, May, June, September (discharge area only) and October, thus establishing some spatial and temporal continuity.

Standard monthly observations were made at permanent stations located within the riprap zone (Fig. 1). The north discharge structure and either the middle or south intake structure were examined regularly. Swims were conducted around the top and base of the structure and a section of riprap 2-3 m wide surrounding the structure. Sampling and swims farther out onto the riprap were intermittently conducted. Observations were also made at a control station outside the riprap area. This station is located halfway between the intake and discharge structures at a depth of approximately 7.6 m, and covers an area parallel to shore 2-3 m wide (dependent upon visibility) extending for a distance of 200 m northward from the north range pole. Supplemental dives were performed on seven occasions, three at non-permanent locations; these dives are discussed in the observations section.

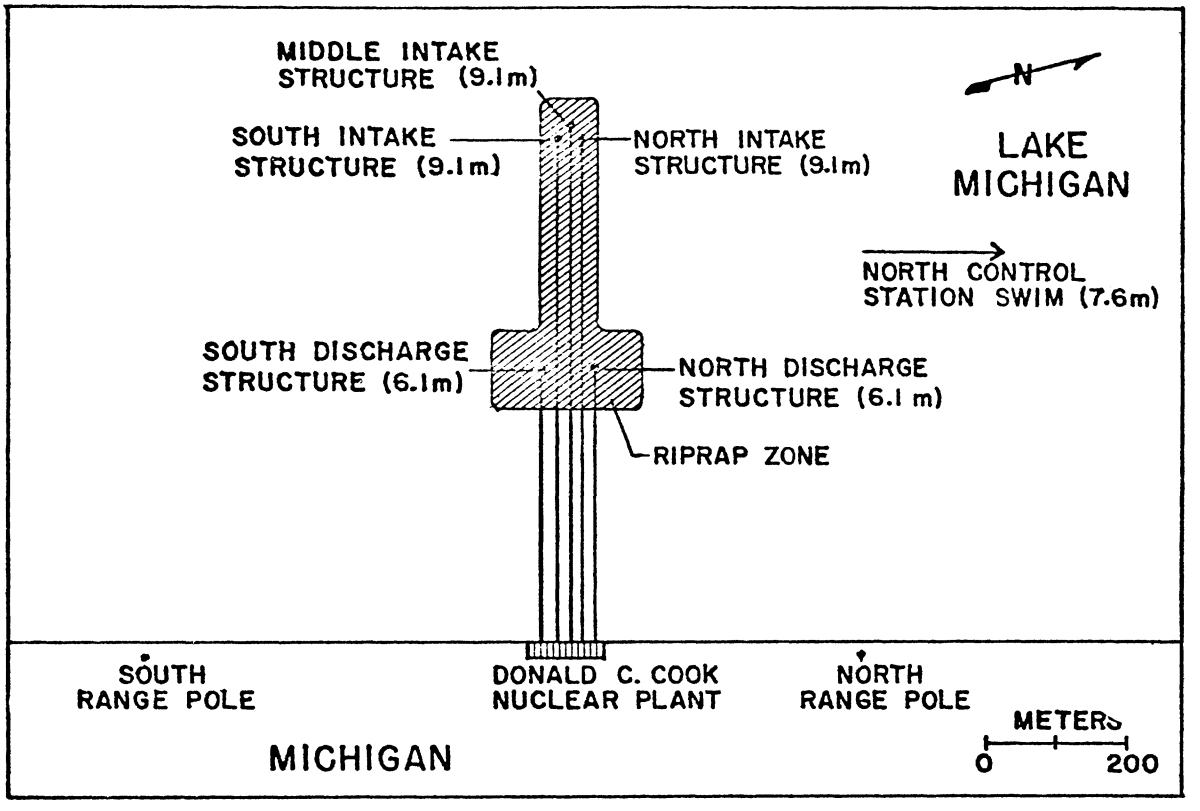

FIG. 1. Map of the Cook Plant study area in southeastern Lake Michigan in 1974.

Observations were made by John A. Dorr III, Gregg R. Gitschlag, David J. Jude, Timothy J. Miller, and Frank J. Tesar. During the dives, observations were written on slates or committed to memory and transcribed on the surface. In all cases, observations made by participating divers were combined and summarized in a dive report.

Because visual observations tend to be subjective, the following terms or phrases used in the report are defined: few = 1-10, many = 10-50, numerous = 50-100, and abundant = more than 100. For the sake of brevity the terms "apart," "high" and "length" were used to describe ripple marks. "High" refers to the trough-to-crest distance, and "length" refers to the distance from one end to the other of an individual ripple mark. Ripple mark direction (the direction from which they were generated) was determined with an underwater compass. "Riprap" refers to the broken

stone surrounding the various intake and discharge structures. "Floc" refers to the loose accumulation of fine particulate material (consisting primarily of sediment, some periphyton and diatomaceous material) which in this area often covers the bottom with a thin (3-10 mm) layer. "Organic debris" refers primarily to terrestrial vegetation such as trunks and branches of trees, roots, leaves, dune grass, etc. An attempt was made to describe the behavior of observed fish. Unless schooling or other social behavior is noted, all fish were solitary individuals; unless specifically noted as juveniles, all fish were adults. The value given for horizontal visibility is an estimate which can vary to ±20%, depending on the distance estimated. Current direction was determined with a compass. Rate of flow was estimated by timing the horizontal transport of suspended material past stationary divers. Surface temperature was taken within 1 m of the surface and bottom temperature within 1 m of the bottom. All times are Eastern Standard Time.

As in 1973 (Dorr 1974) observations were occasionally taken from a predetermined (transect swims) location for the purpose of quantifying visual data (numbers/m^2) and calculating densities, testing equipment and methods, and training personnel to quantify their underwater observations.

During Dives Nos. 5, 6 and 11, a transect 1 m wide and 10 m long (10 m^2) was swum along the bottom beginning at the north, south, east and west sides of the indicated structure; each transect began at the base of the structure and extended outward, perpendicular to the structure. Observations were made by two divers, each observing one half of the transect width. The data from each diver's observations were then pooled and summarized. It should be noted that these transect counts represent numbers of easily visible organisms only. Since the bottom (riprap) was not examined from all angles nor was it overturned, higher actual densities might well be expected. Although exact densities cannot be calculated reliably, the method of observation and bottom type remained similar for all transect swims, thus allowing some relative density comparisons.

OBSERVATIONS

Tables 1 and 2 summarize the standard monthly and supplementary dives performed in southeastern Lake Michigan at the plant in 1974. Observations made during each dive are presented in this section. The dives are presented in the order in which they were performed. Occasionally, limited discussion focusing on a specific observation is also presented in this section, for the purpose of retaining and clarifying the connection between the observation and subsequent interpretation, and to avoid reiteration of observational data which would be necessitated if the discussion were to be presented in a later section of the report.

DIVE NO. 1, 16 APRIL, NORTH CONTROL STATION

The horizontal visibility at working depth was 0.6 m. The Secchi disc reading of 1.2 m was below average for the area, probably caused by three days of northwest winds and waves 3 m high which increased the amount of material suspended in the water. Water temperature at the surface and bottom was 1.6 C, air temperature was 7.2 C. There was no noticeable current, the lake was calm, there was little wind and the sky was clear.

The bottom was quite homogeneous and consisted of well-sorted sand. Areas of gravel or silt were not observed. The floc layer that covered the sand was unusually heavy, 8-10 mm thick, and easily placed into suspension. Ripple marks were noted to be running from the northwest. They were 15 cm apart and 2-5 cm high, and were cross-hatched by smaller ripple marks running from the southwest.

The troughs of the large ripple marks contained a thin layer of organic detritus which consisted primarily of dune grass, wood chips, and plant stems. Empty sphaeriid (fingernail clam) shells were abundant (an estimated 50 to several hundred per m^2) and many live individuals were observed. One live crayfish was noted, and when disturbed swam away from the divers. Fish, macrophytes and other macroscopic biota were not observed.

TABLE 1. Summary of 1974 standard monthly dives in southeastern Lake Michigan at the Donald C. Cook Nuclear Plant.

Dive no.	Date	Time (duration:min)	Location	Depth (m)	Team
1	16 Apr	1630-1700 (30)	North control station	7.6	Dorr, Miller
2	17 Apr	1815-1915 (60)	Middle intake structure	4.6-9.1	Dorr, Miller
4	20 May	2115-2215 (60)	Middle intake structure	4.6-9.1	Dorr, Miller
5	21 May	1420-1525 (65)	South intake structure	4.6-9.1	Dorr, Miller
6	22 May	1050-1155 (65)	North discharge structure	4.0-6.1	Dorr, Miller
7	13 Jun	1535-1605 (30)	South intake structure	4.6-9.1	Dorr, Miller, Tesar, Jude
10	13 Jun	2200-2230 (30)	South intake structure	4.6-9.1	Dorr, Tesar
11	14 Jun	1400-1440 (40)	North discharge structure	4.0-6.1	Dorr, Miller
16	24 Sep	1700-1745 (45)	North discharge structure	4.0-6.1	Dorr, Miller
17	23 Oct	1910-2020 (70)	Middle intake structure	4.6-9.1	Dorr, Tesar
18	24 Oct	1420-1510 (50)	North discharge structure	4.0-6.1	Dorr, Tesar

TABLE 2. Summary of 1974 supplemental dives in southeastern Lake Michigan at the Donald C. Cook Nuclear Plant.

Dive no.	Date	Time (duration:min)	Location	Depth (m)	Team
3	19 Apr	1635-1730 (55)	Riprap area surrounding north intake and discharge structures	4.6-9.1	Dorr, Miller
8	13 Jun	1615-1645 (30)	North discharge structure	4.6-6.1	Dorr, Tesar, Jude
9	13 Jun	1715-1730 (15)	6.1 m contour directly south of the south discharge structure	6.1	Dorr, Tesar
12	14 Jun	1500-1510 (10)	South intake structure	4.6	Dorr, Tesar
13	26 Jun	1705-1735 (30)	South intake structure	4.6	Dorr, Tesar
14	22 Jul	1845-1945 (60)	6.1 m contour directly south of the south discharge structure	6.1	Dorr, Gitschlag
15	23 Jul	1045-1400 (60)	9.1 m contour directly south of the south intake structure	9.1	Dorr, Gitschlag

DIVE NO. 2, 17 APRIL, MIDDLE INTAKE STRUCTURE

Horizontal visibility at working depth was 0.8 m. The low Secchi disc reading of 1.0 m was related to both relatively high turbidity and the loss of light as evening approached. Water temperature was 7.1 C at the surface and 7.3 C at the bottom, air temperature was 12.8 C. There was no noticeable current, the lake was calm, there was little wind and the sky was clear.

The riprap was covered with a layer of floc 10 mm thick, again unusually heavy for the area. The riprap was free of inorganic scrap (pipe, cable, sheet metal, scrap metal, bottles or cans, scour cloth, plastic, etc.) as well as any appreciable amount of organic debris.

One live crayfish was seen. Fish, gastropods, macrophytes and other biota were not observed. A macroscopic examination of the structure and surrounding riprap disclosed no apparent growth of *Cladophora*, in contrast to the luxuriant summer growth observed during 1973 on both the top of the structure and the surrounding riprap.

DIVE NO. 3, 19 APRIL, RIPRAP AREA SURROUNDING NORTH INTAKE AND DISCHARGE STRUCTURES

Horizontal visibility at working depth was 0.8 m. The Secchi disc reading was 1.0 m. Water temperature at the surface and bottom was 6.7 C, air temperature was 15.6 C. There was no noticeable current, and weather conditions were calm and clear.

The purpose of this dive was to attach buoy markers to the north intake and discharge structures. The surrounding riprap area between these two structures was examined briefly. Again a heavy, 10 mm thick layer of floc was noted. Very little inorganic or organic debris was seen on the riprap. Fish, molluscs, crayfish and macrophytes were not observed.

DIVE NO. 4, 20 MAY, MIDDLE INTAKE STRUCTURE

Horizontal visibility at working depth with underwater lights was 3.0-4.5 m. The water temperature at the surface and bottom was 10.0 C, air temperature was 21.1 C. There was no noticeable current, the lake

was calm, and the sky was hazy. Diving conditions were excellent, and underwater visibility was unusually high.

The floc layer was not as thick (less than 10 mm) as observed during the April dives. Very little inorganic or organic debris was observed on the riprap.

Periphyton was noted on top of the structure, with *Cladophora* growing along the outside edge. Since *Cladophora* was not observed on either the structure or the riprap during the April 1974 dives, it is possible that this algae does not become available as a fish spawning substrate until May.

A few crayfish were seen among the riprap. They were solitary, inactive and hiding in crevices. Snails (*Physa integra*) were very abundant. In one area of the riprap, 10 were counted in an area of approximately 0.1 m^2 (1 sq ft).

The following fish species and their behavior were observed:

Species	Number	Location	Behavior
Burbot	1 adult	Top of structure	Resting motionless
Channel catfish	1 juvenile	Top of structure	Resting motionless
Emerald shiner	1 adult	Top of structure	Solitary, slow random swimming
Carp	1 adult	Riprap near base of structure	Slow swimming
Yellow perch	20-30 adults	Near or resting on riprap	Solitary, slow swimming or motionless
Johnny darter	100-200 adults	Top of structure and resting on riprap	Solitary, active and alert
Sculpin	Several hundred	Top of structure and resting on riprap	Solitary, stationary and alert

A burbot approximately 45 cm in length was grasped and squeezed, but exuded no sex products. The carp was swimming steadily and passed by the divers quickly. Most yellow perch appeared to be "resting" or "sleeping" and could be touched or grasped. Johnny darters were very abundant and were seen resting on top of or between the riprap; they

were active, alert and easily frightened. Sculpin were by far the most abundant species of fish; they were solitary and alert. As noted during the 1973 diving operations, burbot, catfish, shiners and perch appeared quiescent at night. Sculpin and darters seemed to be diurnally and nocturnally active. However, they tended to remain concealed among the riprap during the daylight hours.

None of the fish were seen to swim near the sides of the structure or through the intake grids, nor was any schooling behavior observed. It is interesting to note that only one (yellow perch) of the five species of fish most common to the area (alewife, spottail shiner, yellow perch, rainbow smelt and trout-perch) was observed during May 1974 diving operations. In particular, alewives were very abundant inshore during this time of the year, and no explanation can be given at this time concerning the absence of this species at the dive site.

The divers then swam west across the riprap and 10 m onto the sand. No significant biological changes were noted between the areas of riprap and sand examined.

Many pieces of riprap were overturned by the divers but fish eggs were not observed, nor were macrophytes.

DIVE NO. 5, 21 MAY, SOUTH INTAKE STRUCTURE

Horizontal visibility at working depth was 3.5 m. Water temperature at the surface was 13.3 C, 11.1 C on the bottom. Air temperature was 24.5 C, the lake was calm and there was little wind. There was no noticeable current.

A portion of the riprap adjacent to the structure was examined and found to be covered with a thin (3 mm) layer of floc. Periphyton, but no *Cladophora*, grew sparsely on the riprap.

The top of the structure was also covered with a 3 mm layer of floc. *Cladophora* was not growing in the central portion of the top of the crib. Along the extreme edges of the crib it grew sparsely to a length of 4 cm, was green and free of silt. Diving observations have shown that when

Cladophora first appears in the spring, it is initially observed on the upper outside edges of the intake structures. The combination of direct exposure to sunlight, relatively shallow depth (4.6 m--allowing greater light penetration) and beter-than-average water circulation around this projecting edge may stimulate early growth of *Cladophora* at this location.

Upon analysis, a sample of periphyton taken from the top of the structure was found to contain *Cladophora*, the attached diatom *Gomphonema* and the protozoan *Vorticella*.

Transect swims were conducted as described in the methods section and results are summarized in Table 3. The bottom composition remained homogeneous (riprap) throughout all four transect swims. With the exception of the 8.1 snails/m^2 on the north side transect, densities of the organisms observed were usually less than 1/m^2 in each of the four transects. The high snail density on the north side cannot be explained at this time. However, uneven distribution of snails has been noted upon several other occasions. All snails observed were *Physa integra*.

Many snail egg cases (probably *P. integra*) were observed, some containing eggs. Johnny darters were the most frequently observed fish during this daytime dive, contrary to the previous (night) dive when sculpin were most commonly seen. One black bullhead was observed when a piece of riprap was overturned. No other species of fish were noted. All fish were resting on the bottom; pelagic fish were not observed.

At the end of the dive, a piece of riprap bearing a clump of slimy sculpin eggs attached in a mass to its undersurface was overturned. The riprap, with eggs attached, was transported to the laboratory in an 85 liter ice chest filled with lake water, where a hatch of several hundred larvae took place over a period of 10 min to several hours. The larvae were later identified as slimy sculpin (*Cottus cognatus*). During the remainder of the dive approximately 100 more pieces of riprap were overturned but additional eggs were not found.

Macrophytes were not observed. Little organic debris covered the riprap, and no large sticks, logs or accumulations of terrestrial vegetation were seen.

TABLE 3. Numbers of organisms and densities (shown in parenthesis in No./m^2) calculated from four 1 m X 10 m (10 m^2) transect swim observations taken during 1974 in southeastern Lake Michigan near the Donald C. Cook Nuclear Plant.

Transect (compass) point	North	South	East	West	Avg. den.
Date: May 21 (Dive No. 5)					
Location: South intake structure					
Snails (*Physa integra*)	81 (8.1)	11 (1.1)	0	4 (0.4)	(2.4)
Sculpin	1 (0.1)	0	0	0	(<0.1)
Johnny darter	4 (0.4)	4 (0.4)	1 (0.1)	1 (0.1)	(0.2)
Crayfish	0	0	0	0	0
Date: 22 May (Dive No. 6)					
Location: North discharge structure					
Snails (*P. integra*)	0	5 (0.5)	4 (0.4)	0	(0.2)
Sculpin	0	0	0	0	0
Johnny darter	2 (0.2)	3 (0.3)	4 (0.4)	2 (0.2)	(0.3)
Crayfish	0	1 (0.1)	0	0	(<0.1)
Date: 14 June (Dive No. 11)					
Location: North discharge structure					
Snails (*P. integra*)	0	19 (1.9)	1 (0.1)	0	(0.5)
Sculpin	2 (0.2)	0	0	0	(<0.1)
Johnny darter	0	1 (0.1)	1 (0.1)	0	(<0.1)
Crayfish	0	0	0	0	0

DIVE NO. 6, 22 MAY, NORTH DISCHARGE STRUCTURE

Horizontal visibility at working depth was 3.0 m. The Secchi disc reading was 3.7 m. Water temperature was 12.0 C at the surface and 11.1 C on the bottom, air temperature was 21.1 C. There was no noticeable current. During the dive, a storm developed from the southwest which generated 1 m surface waves. However, with the exception of a pronounced decrease in light levels, no effect (current, swells, etc.) of the developing storm was noticed on the bottom.

The riprap surrounding the structure out to a distance of 4.6 to 6.1 m was carefully examined. The riprap on the slot discharge side of the structure varied in diameter from 20 to 90 cm. There was no noticeable accumulation of floc in this area, although a few small (less than 0.6 m diameter), thin (less than 15 cm thick and underlain by riprap) patches of sand were evident. Large patches of sand, troughs or mounds in the riprap were not seen. Pieces of inorganic scrap were common and were scattered randomly over the area. The riprap on the back side of the structure, opposite the slot discharge, was much more homogeneous, with diameters ranging from 15 to 40 cm. There was a light layer of floc covering this riprap, but patches of sand were not observed. The primary differences noted between the riprap surrounding the north discharge structure and that surrounding the south intake structure examined the day before were: the discharge riprap was coarser, had less floc covering it, and patches of sand were not observed anywhere in the intake area.

Transect swims were conducted. During the north swim, many empty snail shells (*Goniobasis* sp.) and one severely decayed yellow perch were noted. Twelve caddisfly larvae were counted during the west transect swim. The outer 5 m of the east transect swim extended beyond the riprap onto the sand, therefore the change in bottom composition may have affected the distribution and subsequent count of organisms. Again, uneven distribution of snails is evidenced by the density variation between the north transect swims on 21 May ($8.1/m^2$) and 22 May (0). In this case, the difference in location may account for some of the density variation.

During a general examination of the riprap area surrounding the discharge structure, one dead sculpin and one unidentifiable dead fish were noted. Dead fish have been seen during diving operations on only one other occasion, a dive made 8 km south, off Warren Dunes State Park on 18 June 1973, but never in the vicinity of the Cook Plant. Caddisfly larvae were numerous, and snail shells were common. Snails were more frequently observed during both the previous day and night dives (Nos. 4 and 5) in the vicinity of the south intake structure than during this dive in the area of the north discharge structure. No explanation can be offered for this difference in distribution. Free-swimming (pelagic) fish were not observed; fish seen were all solitary adults resting on the bottom.

The structure and riprap were examined for *Cladophora* or other attached algal growth, but none were noted. A large section of a tree (the stump and a portion of the trunk) approximately 12 m in length with a trunk base diameter of 1 m was found lying within 3 m of the north side of the structure, with the stump pointing northwest. The tree had no apparent macroscopic biota attached to it and remained firmly in position until July when it was removed mechanically by a crane. Branches and debris from terrestrial plants were scattered sparsely over the riprap. Macrophytes were not observed.

As in the previous dive, 75-100 pieces of riprap were overturned and examined for fish eggs. One piece had a small clump of sculpin eggs attached to the underside. These eggs were transported to the laboratory in a manner similar to that described in Dive No. 5. However, hatching did not occur. Microscopic examination of the eggs did show that several stages of embryonic development had taken place.

DIVE NO. 7, 13 JUNE, SOUTH INTAKE STRUCTURE

Horizontal visibility at working depth was 3.0 m. The Secchi disc reading was 3.5 m. Water temperature at the surface was 15.3 C and 15.0 C on the bottom, air temperature was 24.0 C. The lake and the wind were calm. A slight current to the northeast was detected. The bottom

was not examined carefully, but a floc layer of average (5-8 mm) thickness was noted.

Cladophora was growing on the edges of the structure, the top of the ice guard and in isolated patches on the central portion of the top of the structure. One snail (*Physa integra*) was noted on the riprap, and 5-10 crayfish were seen hiding between the rocks.

More than 50 johnny darters were counted, randomly dispersed and resting on the riprap. Twelve yellow perch were seen randomly swimming beside the structure and behind the oblique ice guards. Eight-to-ten slowly swimming, solitary alewives were observed within 3 m of the bottom. Sculpin were not observed, which was unexpected since they are very abundant in the area.

Thousands of spottail shiner eggs were observed attached to *Cladophora* growing on the top of the structure. Where the *Cladophora* grew densely, egg counts reached 1-2/cm^2 (approximately 10/sq in). Most of the eggs were clear, unbroken and not fungused, indicating viability. Samples of these eggs were collected during two subsequent dives (refer to Dives 12 and 13 for further discussion).

DIVE NO. 8, 13 JUNE, NORTH DISCHARGE STRUCTURE

Horizontal visibility at working depth was 3.0 m. The Secchi disc reading was 3.5 m. Water temperature at the surface was 15.3 C and 15.0 C on the bottom. Although the upper 2 m of the water column was only 0.3 C warmer than the underlying water, this temperature differential was readily detectable to the divers' hands and faces. It is possible that even such a slight thermal stratification could be detected by and affect the vertical orientation of thermally sensitive organisms. The air temperature was 23.9 C and weather conditions were calm. There was no noticeable current.

Two johnny darters were observed resting on the riprap; no other fish were observed. The purpose of this dive was to orient new divers and to test a small centrifugal pump designed to sample planktonic organisms and fine sediment on or immediately above the bottom. This

method of sampling might be applied to areas where near or on bottom sampling is desirable, but where conditions (rocks, logs, weeds, etc.) prevent effective use of conventional sampling devices (plankton nets, sleds, or ponar grab samplers). The pump was effective and may be incorporated into future sampling operations.

DIVE NO. 9, 13 JUNE, 6.1 M CONTOUR DIRECTLY SOUTH OF THE SOUTH DISCHARGE STRUCTURE

Horizontal visibility at working depth was 3.0 m. The Secchi disc reading was 3.5 m. Water temperature at the surface was 15.3 C and 15.0 C on the bottom. Air temperature was 23.9 C, weather conditions were calm, and there was no noticeable current. The area examined consisted of a transect 3 m wide by 160 m long. The transect began directly out from the south range pole (Fig. 1) in 6.1 m of water and proceeded south along the bottom. The purpose of the dive was to examine the fishing position and entrapment mechanism of a 2 m x 160 m multifilament, nylon-twine, sinking gill net, and to investigate the bottom area immediately adjacent to it.

The bottom consisted of well-sorted sand with no noticeable floc covering it. Large ripple marks 15-20 cm apart, 2.5 cm high and 60-90 cm in length were running from the northwest and were cross-hatched by smaller asymmetric ripple marks running from the west and southwest.

Loose algae (*Spirogyra*) had accumulated in patches 2.5-7.5 cm in diameter with a frequency of 2-5 patches/m^2. Clumps had been collected during the previous few days in seines, trawls, gill nets and plankton nets. Aggregations of this algae had not been noticed during previous dives in the area. Since the algae was unattached, it may have been washed into the area. Macrophytes and organic debris were not observed.

Observations pertaining to the fishing position and entrapment mechanism of the described net were:

1) Tangles or twists in a 2 m high net can render a 2-3 m section ineffective.

2) The use of spreaders at each end of the net greatly increased the width and effectiveness of the first 3 m of the net.

3) Algae accumulation on the netting mesh greatly increased the visibility of the net.
4) Close mesh sections (1.3 cm bar mesh) of the net were visually more prominent than the large mesh sections (10.2 cm bar mesh).
5) Direction of fish entry, i.e., direction of their movement, was easily determined; 75% of the fish entered from the west side (the net was set north to south, parallel to shore).

A total of 683 alewives, 9 yellow perch and 8 spottail shiners were taken in this net, primarily in the first three of 11 panels of progressively increasing mesh size. The net was set from 0610-1830 hr (12 1/4 hr) and the dive was made during the last 2 hr. Two points should be noted: first, the efficiency of the panels in which the fish were caught was greatly reduced by the end of the set. The panels, which contained alewives, were very conspicuous to the divers because the fish were actively twisting and turning. Second, although fish were obviously present in the area of the dive and visibility was good, free-swimming fish were not observed. This suggests that failure to observe fish does not exclude their presence from the area of observation. Most likely, diver estimates of pelagic fish abundance are quite rough. The fish probably sense the divers' presence and retreat from the area before they are visible to the divers. Observations of fish in our study area, where the visibility seldom exceeds 4 m, can best be made at night with underwater lights and when the visibility is 3-4 m. Once in the water, if the divers remain immobile they will reduce the tendency for their movements to disturb fish in the area. Our observations indicate that many of the fish in our study area appear to be less sensitive to stimuli (movement, vibration, etc.) at night.

DIVE NO. 10, 13 JUNE, SOUTH INTAKE STRUCTURE

Horizontal visibility at working depth with underwater lights was 2.3 m. Water temperature at the surface was 15.3 C and 15.0 C on the bottom. Air temperature was 15.6 C, the lake was calm, there was little wind and the air was cool. No noticeable current was present.

A few crayfish were seen hiding among the riprap. Snails (*P. integra*) were very abundant although, as has been noted consistently during both transect swims and general observations, their distribution was uneven. The density of snails at one location was estimated to be 100-150/m^2 (10-15 sq ft). Snail egg cases were very abundant, but their distribution was also uneven.

During the observation period, many fish were seen on top of the structure. Spottail shiners were abundant, with a density in the first meter of water above the top of the structure estimated to be 10/m^3. These fish appeared to concentrate near the top of the structure and none were seen while descending or ascending.

The spottails were swimming randomly, not schooling or spawning, and when captured and squeezed did not exude gonadal products. Spottail shiners were not observed at a level below the top of the structure. It appeared that sculpin were less abundant than during the previous night dive. Eight johnny darters were noted, all resting on the riprap.

Approximately 20-30 alewives were observed scattered throughout the 4.6-9.1 m depth interval, all adults, solitary and not observed to remain stationary or approach the riprap. The infrequency of observed alewives was unexpected because, during fishing operations in the area the night before, extremely large numbers of alewives were seen "jumping" and schooling on the surface. However, if the alewives were concentrating at the surface, they might not be observed in large numbers at the depths (4.6-9.1 m) where we were diving.

The primary intent of this dive was to contrast day/night levels of species diversity, abundance and behavioral activity. As noted on previous occasions, the species diversity and abundance of fish and the number of snails observed was much higher at night than during the day.

DIVE NO. 11, 14 JUNE, NORTH DISCHARGE STRUCTURE

Horizontal visibility at working depth was 3.0 m. The Secchi disc reading was 3.5 m. Water temperature at the surface and bottom was 15.0 C. Air temperature was 22.2 C, the lake was calm and there was little wind. A slight current to the northeast was present.

The bottom in the vicinity of the slot (jet) discharges was examined for scour; none was observed. Inorganic scrap was scattered lightly over the riprap on the slot side of the structure. On the north side of the structure, the riprap extended outward 5 m at which point the sand bottom began. The sand/riprap boundary was located a similar distance from the structure on the northeast side. The large tree stump described in Dive No. 6 appeared to have maintained its position. There was no evidence of *Cladophora* growth on either the structure or the riprap.

Transect swims were conducted. The number of snails observed in the south transect was higher this month than during the preceding month (Dive No. 6) and johnny darters were seen less frequently in all four transects. Many snail egg cases were noted during the east transect swim. Five empty snail shells (*P. integra*) were counted during the west transect swim, as well as five juvenile alewives and one adult carp.

A fragment of a large (5-6 diameter cm) gastropod shell was collected; not enough was present to make an identification. Johnny darters were numerous in certain areas of the riprap, and alewives were observed swimming in small schools of less than 50 fish. The observation of the large fish, a carp approximately 60 cm in length, was unusual, as large fish in this area are seldom seen by divers. Biological activity was higher this year than observed at this location and time during the previous year (17 June 1973).

Two samples of periphyton were collected, one from the riprap and one from the top of the structure. A qualitative analysis of the samples is summarized in Table 4. Four species of green algae and 13 species of diatoms were found in the sample taken from the riprap. Five species of green algae, one species of blue-green algae and 14 species of diatoms were found in the sample taken from the top of the structure.

DIVE NO. 12, 14 JUNE, SOUTH INTAKE STRUCTURE

Horizontal visibility at working depth was 3.5 m. The Secchi disc reading was 3.5 m. Water temperature at the surface was 15.0 C. Air temperature was 22.2 C, the lake was calm, there was no wind and the sky was overcast. A slight current to the northeast was present.

TABLE 4. Algae and diatoms observed in qualitative analysis of periphyton collected in southeastern Lake Michigan near the Donald C. Cook Nuclear Plant during 1974 diving operations. ND = North Discharge Structure, MI = Middle Intake Structure.

	Sampling location				
	Riprap			Top of structure	
	14 Jun	23 Oct	24 Oct	24 Jun	23 Oct
	ND	MI	ND	ND	MI
Green algae					
Cladophora sp.		X	X		X
Closteriopsis sp.	X				
Oocystis sp.			X		
Pediastrum duplex				X	
Pediastrum tetras				X	
Scenedesmus quadricauda	X			X	
Spirogyra sp.	X			X	
Ulothrix sp.	X			X	
Blue-green algae					
Oscillatoria sp.				X	
Diatoms					
Amphipleura pellucida				X	X
Amorpha ovalis	X				
Amorpha sp.				X	
Asterionella formosa	X			X	X
Cocconesis sp.			X		
Cymatopleura solea	X			X	
Cyclotella ocellata				X	X
Cymbella ventricosa					X
Cymbella sp.	X	X			
Diatoma tenue v. *elongatum*	X			X	
Diatoma tenue			X		X
Fragilaria crotonensis	X			X	X
Gomphonema sp.			X		X
Gyrosira sp.				X	
Melosira granulata	X				
Melosira varians					X
Melosira sp.		X	X		
Navicula sp.	X	X	X	X	X
Nitzschia sp.	X	X	X	X	X
Rhizosolenia eriensis	X				
Rhoicosphenia curvata					X
Stephanodiscus niagarae	X			X	
Stephanodiscus minutus					X
Stephanodiscus tenuis					X
Stephanodiscus sp.	X				
Surirella angusta		X		X	
Surirella ovata v. *pinnata*				X	
Synedra ulna				X	
Synedra sp.					X
Tabellaris fenestrata	X				X

The purpose of this dive was to collect samples of fish eggs attached to *Cladophora* growing along the top edges of the structure. Egg samples were collected and incubated in the laboratory. Five spottail shiner larvae were hatched. This identification was based upon measurements of egg diameters, knowledge of the concurrent distribution and gonad condition of fish species in the area, use of fish identification keys and comparison of the hatched larvae with specimens of known identity.

Alewives and yellow perch were observed swimming around the top and sides of the structure. The base of the structure and surrounding riprap were not examined.

DIVE NO. 13, 26 JUNE, SOUTH INTAKE STRUCTURE

Horizontal visibility at working depth was 1.8 m. The Secchi disc reading was 2.7 m. Water temperature at the surface was 15.0 C and 13.5 C on the bottom. Air temperature was 14.0 C and weather conditions were calm. Although there was no noticeable current, surface wave action was quite evident on top of the structure.

The purpose of this dive was to collect additional samples of fish eggs observed during previous dives in the area (Dives 7, 10 and 12). These eggs were first observed 13 days prior. By the time of this dive, the number of eggs attached to the *Cladophora* was greatly reduced. Also, the majority of the eggs were now either empty shells or covered with fungus. The *Cladophora* was growing in uniform density along the top edge of the structure and was approximately 7.5 cm in length. One adult yellow perch was observed.

DIVE NO. 14, 22 JULY, 6.1 M CONTOUR DIRECTLY SOUTH OF THE SOUTH DISCHARGE STRUCTURE

Two core samples were taken at each of five stations located along the 6.1 m depth contour. The first station was 100-200 m south of the discharge area, and each of the following four stations was approximately 100 m south of the preceding one. Besides taking core samples, the divers had an opportunity to observe the lake bottom at locations outside

the riprap area. Analysis of the core samples showed both the presence and wide variation in density per m^2 of fish eggs, probably alewife. Analysis and discussion of these core samples can be found in Mozley (1975).

Horizontal visibility at working depth was 1.5-1.8 m. Water temperature at the surface was 15.6 C, 15.0 C on the bottom. The water was unusually cold for this time of the year as the result of an upwelling accompanying offshore winds. Air temperature was 17.2 C, and there was a slight northerly current.

The bottom consisted of well-sorted sand which varied from station to station in mean grain size and degree of compactness. At some of the stations, the coring tubes were easily pushed into the bottom (depth of the core was 15 cm) while at other stations the tubes were forced into the bottom with some difficulty. Ripple marks at the five stations were constant in size, 10 cm apart, 4 cm high and 60-90 cm in length, running from the northwest. Silt pockets were not observed. Although a few empty shells and shell fragments were noted in the troughs of the ripple marks, no live molluscs were seen. Live fish were not observed; one dead alewife was seen. Algae, macrophytes and organic debris were not observed.

DIVE NO. 15, 23 JULY, 9.1 M CONTOUR DIRECTLY SOUTH OF THE SOUTH INTAKE STRUCTURE

This dive was similar to Dive No. 14. Two core samples were taken at each of five stations located along the 9.1 m depth contour. The first station was 100-200 m south of the intake area, and each of the following four stations was approximately 100 m south of the preceding one. Two other locations in the area were examined, and two 100 m swims were conducted during the course of the dive.

Horizontal visibility at working depth was 1.5 m. Water temperature at the surface was 15.6 C, 7.8 C on the bottom. The thermal interface was very well-defined, but the depth at which it occurred was not determined. A noticeable current to the southeast was present. Cold-water upwelling, poor visibility and rough surface conditions combined to make diving conditions poor.

At the five coring stations and two other locations, as well as during the two 100 m swims, the bottom type varied more than had been observed during previous dives in this area south of the riprap zone. The increase in variability may have resulted from the larger number of observation stations and the greater alongshore distance covered, compared to previous dives such as No. 9 when only 160 m was swum. Bottom types encountered included: 1) hard, fine sand; 2) hard, fine sand with patches of loose algae and organic debris present (patches were 2.5-7.5 cm in diameter and occurred with a frequency of approximately $1/m^2$); 3) soft sediment 2.5-5.0 cm thick, overlying hard sand; 4) coarse sand displaying large ripple marks. This final bottom type was encountered at the location furthest from the plant--approximately 2000 m. The large ripple marks were 20 cm apart, 3 cm high and running from the northwest. Ripple marks observed at all the previous locations examined were 10 cm apart, 1.5 cm high and running from the northwest.

As in the previous dive, live molluscs were not observed although shell fragments were present at several locations. No live fish were observed. Four dead alewives were counted. Macrophytes were not observed.

DIVE NO. 16, 24 SEPTEMBER, NORTH DISCHARGE STRUCTURE

Horizontal visibility at working depth was 1.8 m. The Secchi disc reading was 1.5 m. Water temperature at the surface and bottom was 17.0 C. Air temperature was 23.9 C, and the sky was partly cloudy. A current to the north was noted.

Both the top of the structure and the riprap were covered with a thin layer of floc (3 mm). The riprap surrounding the structure was examined for scour, but none was observed. The bottom area to the north and northwest of the structure was examined out to the riprap/sand boundary. This area appeared to be the same as when last examined (June, Dive No. 11). Limited water pump circulation from the plant had taken place between July and September.

Cladophora was growing on top of the structure to a length of 3-4 cm. Growth was uneven but extensive and extended at least 1.8 m inward from

the edge of the structure. This was the first occasion in 1974 during which *Cladophora* was observed to be growing on this structure. *Cladophora* was not observed growing on the riprap surrounding the structure. Relatively large (1-3 m diameter) loose aggregations of organic debris (planks, tree branches, small stumps, leaves and dune grass) were randomly scattered over the bottom on the south and east sides of the structure. Macrophytes were not observed.

Snails (*P. integra*) were abundant on the riprap. Gastropod (*P. integra* and *Goniobasis* sp. or *Pleurocera* sp.) and sphaeriid shells had accumulated in abundance on small patches of sand adjacent to the base of the structure.

Sculpin and crayfish were abundant but were hiding beneath the riprap and were frequently not observed unless the stone was overturned. Two johnny darters were seen on the sand north of the riprap; none were seen on the riprap. Pelagic fish were not observed.

DIVE NO. 17, 23 OCTOBER, MIDDLE INTAKE STRUCTURE

Horizontal visibility at working depth was 1.2 m with underwater lights. Water temperature at the surface and on the bottom was 13.0 C. Air temperature was 16.7 C; the lake and the wind were calm. Almost constantly for 5 weeks prior to this dive, the weather was inclement and seas had been rough. During this dive, both a current to the north and surface wave action were noticeable.

The floc layer on the top of the structure and the riprap was of average thickness, 5 mm. This was somewhat unexpected, since after 5 weeks of increased water mixing and sediment suspension, either an unusually heavy settling out of floc or removal of floc from the area might have been expected.

Cladophora 2-4 cm in length was growing on top of the structure and sparsely on the sides of the ice guards. The upper surface of the riprap was also covered by *Cladophora* 1-2 cm in length. The algae on the structure and the riprap was examined for fish eggs; none were observed. Numerous pieces of riprap were overturned but fish eggs were not observed among the stones. However, bryozoa were growing on the sides of

two pieces of riprap. The combination of high oxygen levels, clear water, dim light and a relatively silt-free surface (sides of riprap) apparently constituted a suitable habitat for bryozoa. This was the first observation of this organism. Upon casual examination, bryozoan colonies such as these could be mistaken for snail egg masses, so care will be taken in the future to distinguish between the two. Little organic debris was encountered. Macrophytes were not observed.

One piece of riprap collected from the southwest side of the structure was covered with a thin mass of freshwater sponge. This was the first time that sponge was observed by divers, although it had been collected previously from the intake forebay of the plant during entrainment sampling procedures.

Even when the riprap was overturned, crayfish were not observed. This was contrary to summertime observations, when crayfish were often quite abundant. Snails (*P. integra*) were very abundant but uneven in their distribution. In one area, counts indicated an approximate density of at least 80 snails/m^2, with the true density possibly being much higher. Other areas appeared devoid of snails.

Approximately 10 large sculpin were counted on top of the structure. They could be approached to within a few centimeters without being disturbed. When disturbed, they swam only a meter or so before coming to rest. The density of sculpin on top of the structure was estimated at 0.5 fish/m^2. Several sculpin were seen resting on the oblique sides of the ice guards, and 50-75 were seen between the riprap. As with the snails, the density of sculpin varied from zero to several fish per m^2.

One large and one medium sized adult lake trout were observed briefly as they swam slowly through the range of the underwater lights. The sighting of large fish, particularly salmonids, was unusual; perhaps these trout may have been attracted to the underwater lights. No other species of fish were observed.

A qualitative analysis of the periphyton samples collected from both the top of the structure and the riprap is presented in Table 4. Compared with the other samples presented in the table, the sample taken from the riprap contained relatively few species of algae and diatoms.

DIVE NO. 18, 24 OCTOBER, NORTH DISCHARGE STRUCTURE

Horizontal visibility at working depth was 3.5 m. The Secchi disc reading was 4.0 m. Water temperature at the surface and the bottom was 13.0 C. Air temperature was 21.1 C, the lake was calm and there was no wind. A very slight current to the northeast was present. As noted in Dive 17, the weather preceding this dive had been inclement.

Both the top of the structure and the riprap were covered with a relatively heavy layer of floc 5-8 mm thick. The riprap surrounding the structure was examined carefully, and a trough was noted on the east side of the structure, running perpendicularly outward. Beginning 1 m from the base of the structure, it was 3 m long, 1 m deep, 2.5 m wide at the top and 1.2 m wide at the base. The bottom of the trough consisted of sand and the sides of 7-15 cm diameter riprap. The sand extended up to the base of the structure, and at one point midway along the trough a diver dug 30 cm into the sand bottom but failed to encounter riprap. Indications of riprap scour were not observed on the south, west, or north sides of the structure. A swim of approximately 400 m was conducted from the south side of the north discharge structure to a point 100 m southwest of the south discharge structure. Nothing unusual was observed.

Cladophora was growing on top of the north discharge structure and was considerably longer and more luxuriant than that observed on the top of the middle intake structure (Dive No. 17). During the 400 m swim, *Cladophora* was also seen growing on the riprap. In general, the *Cladophora* growth was longer and more luxuriant in the discharge area, Dive No. 18, than in the intake area, Dive No. 17.

Snails (*P. integra*) were abundant on the riprap adjacent to the south and east sides of the structure. Again distribution was uneven. One crayfish was observed while overturning pieces of riprap. Four sculpin were seen hiding among the riprap.

Small (0.3-1.0 m diameter) scattered patches of organic debris consisting of leaves, roots, branches and dune grass were noted on the riprap to the west and south sides of the structure. Macrophytes were not observed.

A qualitative analysis of a periphyton sample collected from the riprap is presented in Table 4. No sample was taken from the top of the structure. One species of green algae and 15 species of diatoms were identified.

DISCUSSION

1) Table 5 summarizes the species of fish observed during 1973 and 1974 diving operations.

TABLE 5. Summary of fish species observed during 1973 and 1974 diving operations in southeastern Lake Michigan, near the Donald C. Cook Nuclear Plant. Species are listed by location and date in order of descending frequency of observation.

Location	1973	1974
Area of intake structures (riprap)	Sculpin	Sculpin
	Johnny darter	Johnny darter
	Alewife	Alewife
	Yellow perch	Yellow perch
	Spottail shiner	Not observed
	Trout-perch	Not observed
	Not observed	Carp
	Not observed	Lake trout
	Not observed	Burbot
	Not observed	Emerald shiner
	Not observed	Channel catfish
	Not observed	Black bullhead
Area of discharge structures (riprap)	Sculpin	Sculpin
	Johnny darter	Johnny darter
	Yellow perch	Not observed
	Not observed	Alewife
	Not observed	Carp
Areas outside the riprap zone	Johnny darter	Not observed

A total of twelve species have been observed during the two field seasons. In 1974, one species of fish very common to the area, spottail shiner, was not seen. Rainbow smelt have never been observed by our divers, probably because the adult fish spawn inshore in the early spring prior to the commencement of diving operations and then migrate offshore, remaining there past the end of the diving season.

Large fish are seldom observed by divers. Demersal fish, such as darters and sculpin, are more frequently observed by divers than pelagic fish. When a diver's presence is sensed, pelagic fish tend to retreat from the area, whereas demersal fish hide on the bottom or between the riprap. Fishing efforts have shown that in this area lake trout concentrate inshore during the fall and are most active at night. Although only one night dive (No. 17) was performed during the fall, two lake trout were observed. Prior to this, lake trout had never been observed by our divers. Additional data from fall nighttime diving should continue to document the known inshore concentration of these fish during this time of the year, and their predominantly nocturnal activity.

2) Fish eggs were observed during two months of diving activity. In May, slimy sculpin eggs were collected from riprap in both the intake and discharge structure areas. During June, spottail shiner eggs were collected from *Cladophora* growing on top of the south intake structure. In both cases the eggs were attached, not pelagic, and larvae were hatched from them in the laboratory. Two conclusions may be drawn from these observations. Since the eggs were attached (not pelagic), spawning of slimy sculpin and spottail shiners does occur in the area with *Cladophora* and riprap serving as substrates. This observation is supported by observations made in June 1973, when our divers saw spottail shiners spawning in the *Cladophora* attached to the south intake structure and collected samples of their eggs. Second, based on the advanced stage of embryonic development of the slimy sculpin eggs and the number of empty spottail shiner egg shells observed, it can be safely assumed that in this area the eggs of these two fish species incubated and hatched successfully during 1974.

3) Crayfish were observed during every month of diving. As indicated by observations in the individual dive reports, the abundance of crayfish varied greatly over both space and time.

4) *Physa integra* was the most frequently observed gastropod and was seen during all months that diving operations were conducted. Shells from either the genus *Goniobasis* or *Pleurocera* were collected. However, poor condition prevented identification at the species level.

5) Sphaeriid (fingernail clam) shells were frequently observed. Live specimens were not often seen, probably because only the exposed surface of the bottom was examined, not the underlying strata.

6) Macrophytes were not observed on any occasion.

7) Eight species of green algae, one species of blue-green algae and 30 species of diatoms were noted in samples collected in the vicinity of the Cook Plant (Table 4). Only one green algae (*Spirogyra* sp.) was observed outside the riprap area.

8) *Cladophora* was not seen on the south intake structure in April but was present by May and remained through the last dive of the field season (October). *Cladophora* was not observed on the north discharge structure in April, May or June. Dives were not performed in this area during July or August. *Cladophora* was first noted on the north discharge structure in September and remained through the last dive of the field season. It was observed only sporadically on the riprap in the intake and discharge areas; growth was unusually sparse and occurred predominately during the summer months. Generally, the growth of *Cladophora* in this area appears to reach a seasonal maximum length and density between late June and July. This maximal growth level is maintained through early September. It then probably tapers off in late fall as temperatures fall and light levels diminish, reaching a minimum in late winter or early spring. Refer to Dive No. 4 for a discussion of the seasonal availability of *Cladophora* spawning substrate.

9) The floc layer (consisting primarily of sediments, organic detritus and diatomaceous material) varied from less than 3 mm to

approximately 10 mm in thickness, depending upon the location and the date; 5 mm represented a layer of average thickness. The floc layer was much lighter outside the riprap area than within it.

10) Dead fish and patches of organic debris were occasionally observed. However, during the annual late-spring alewife dieoff, dead fish were still only infrequently observed on the bottom.

11) With the exception of Dive No. 18, no scour or other significant disturbances of the riprap were observed.

12) As the divers swam along the bottom, the intensity of reflected light noticeably decreased as they passed from sand to riprap. Pelagic organisms might be attracted to or repelled from an area such as the riprap, where bottom reflected light levels are lower than the surrounding area.

13) The distribution of snails, crayfish and other biota often appeared uneven (Table 3). It may well be that the distribution of many biota (speaking primarily of demersal organisms in the case of diving observations) is uneven. Also, the methods, area examined and frequency of observations (including all diving observations) may have been insufficient to determine any overall patterns of unevenness or continuity.

14) During any monthly series of dives, observed biological activity and diversity was higher at night than during the day and was much higher within the riprap area than outside it.

15) Transect studies (Table 3) were conducted for the purpose of developing methodologies for quantifying observations. Although monthly and seasonal (comparing Table 3 with 1973 transect observations) variation occurred, density expressed as number of organisms/m^2 remained between 0-10/m^2.

CONCLUSION

The seasonal trend in biological activity and diversity, as observed

by divers, appears to begin with a sharp late-spring increase (between early April and mid-May), reaching a maximum during the summer months and then tapering off gradually in the fall, probably between mid-September and late-November. In general, this observed pattern is supported by concurrent sampling studies. Compared to the surrounding inshore zone of the lake (30 m or less), the riprap area appears to attract fish and invertebrates, possibly because it offers greater shelter, an increased supply of food or simple physical attraction. This attraction which concentrates fish and invertebrates was observed during 1973 and again in 1974. The end result is the establishment of a small ecosystem which is atypical of the surrounding area.

1975 PROGRAM OBJECTIVES

A standard series of five monthly (April-November) observational dives is scheduled. They will include day and night observations in the areas of the south intake and discharge structures and at control stations outside the riprap. Operations, observations and analysis will include:

1) Observations for:

   Scour and general status of the riprap
   Suspended material and floc deposition
   Inorganic and organic debris and decaying material
   Attached algae/periphyton - visual analysis and monthly sampling
   Macrophytes
   Crayfish, molluscs and other macro-invertebrates
   Fish, fish eggs and fish larvae

2) Limited observations in the plume in an area to the north and outside of the riprap area.

3) Supplemental sampling operations such as coring, if such sampling is warranted.

4) An attempt will be made to quantify observations whenever possible, for the purpose of facilitating comparisons in space and time.

Quantification efforts will be emphasized in planned transect swim studies. An example of the recording format to be used during observations is presented in Figure 2, for the purpose of illustrating the manner and direction towards which our quantification efforts are proceeding.

5) Day-night comparisons in faunal diversity, abundance and activity.

6) Comparison of floral and faunal diversity, abundance and activity in the areas of the intake structures, discharge structures and

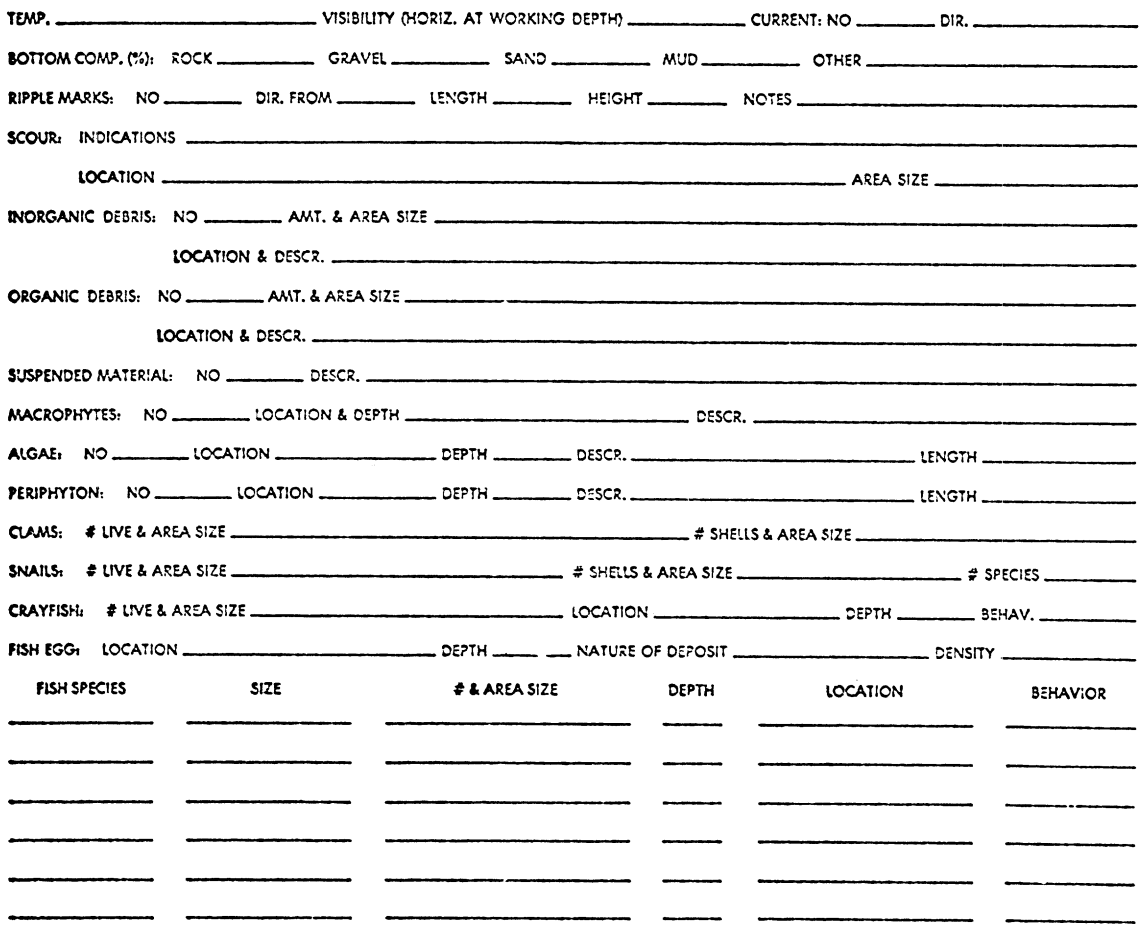

FIG. 2. Underwater data-recording format to be implemented during 1975 diving operations in southeastern lake Michigan near the Donald C. Cook Nuclear Plant.

control stations. Comparisons will be made on a diel, monthly and seasonal basis.

7) General visual analysis of the physical and biological status of the area near the Cook Plant.

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